



DUIKER

NORTH AMERICAN REGIONAL STUDBOOK

Current as of 15 March 2002

Chris Pfefferkorn – Studbook Keeper



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MESSAGE FROM THE STUDBOOK KEEPER

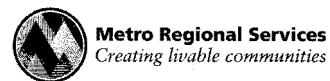
Duikers may not be the charismatic mammals that zoos are known publicly for, but they represent one of the conservation dependent animals and offer zoos a chance to work with a unique animal about which very little is known. In the wild, they are one of the most important sources of bush meat for indigenous people and many of the larger carnivores. As frugivores, they also serve an essential role in seed dispersal and many other ecological niches. For me, the opportunity to bring three more of these species into a managed population will offer zoos a chance to ensure their survival which will add to our ex-situ study potential and help zoo guests understand the importance of species diversity.

I am pleased to present the second complete edition of the North American Studbook for the duiker species; bay duiker, black duiker and red-flanked duiker. Due to the North American population of zebra duikers consisting of only two males, they will no longer be included in the duiker studbook. Records will continue to be maintained and if a viable population becomes established in North America a published studbook for this species will take place.

I want to thank all of the duiker holding institutions (especially the registrars) who supplied information for this book. I especially want to thank the Oregon Zoo staff for their assistance in completion and publication of the studbook, most notably Mike Keele, Assistant Director Animal Collections, David Kato, from our zoo's Design Division, and Jamie Irvine for Graphic Design support. Special thanks go to Jeff Holland of the Los Angeles Zoo, for his input and support of captive duikers.

I would encourage anybody who has information, corrections or addition concerning this studbook to please contact me.

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INTRODUCTION

The 2002 second edition of the North American Regional Studbook for Duikers is a living document produced for use in statistical analysis and population management of three of the nine species found in captivity in the North American Region. This studbook is restricted to the North American Region, countries within the region in which the population is currently held is restricted to the United States. At the time of publication, the three species of duiker covered in this studbook are not believed to be held in other institutions in the Americas outside of the United States.

The nine species in captivity in the North American Region are:

Yellow-backed Duiker (*Cephalophus sylvicultor*)
 Blue Duiker (*Cephalophus monticola*)
 Jentinks Duiker (*Cephalophus jentinki*)
 Bay Duiker (*Cephalophus dorsalis*)
 Black duiker (*Cephalophus niger*)
 Red-flanked Duiker (*Cephalophus rufilatus*)
 Zebra- banded Duiker (*Cephalophus zebra*)
 Common Duiker (*Sylvicapra grimmia*)
 Maxwell's Duiker (*Cephalophus maxwelli*)

Currently a Studbook exists for the Yellow-back Duiker and Blue Duiker. Linda Rohr, Franklin Park Zoo is the Studbook Keeper for the Yellow-back Duiker and Joe Roman, Virginia Zoological Park is the Studbook Keeper for the Blue Duiker. This Studbook covers the Bay Duiker, Black Duiker, and Red-flanked Duiker. The Jentinks Duiker and Zebra-banded Duiker are not managed under a studbook at this time.

There are two different common names used for one of the duikers found in the studbook, it is as follows:

Cephalophus dorsalis - Bay Duiker or Black-back Duiker

This species will be referred to by it's common name in the studbook as it is listed by ISIS (International Species Information System). ISIS lists *Cephalophus dorsalis* as the Bay Duiker.

The data in this edition is current through March 15, 2002. Although every attempt was made to be as accurate as possible assumptions had to be made and errors do exist. Assumptions made were:

- All wild caught individuals were parent raised.
- Any animal that was transferred out of the regional scope of the studbook or if information could not be obtained concerning an individuals location is considered lost to follow up (LTF).
- Birth dates were estimated at one year prior to the first recorded event for the individual.

The data in this studbook is meant to be as complete and informative as possible, any comments, corrections or additions are welcomed and would be greatly appreciated.

SECTION I

NATURAL HISTORY

The word "duiker" comes from the Afrikaans word *duikerbok*, which means "diving buck", a characteristic threat response of the duikers. When alarmed or threatened, duikers will "dive" into the undergrowth. *Cephalophus* is from the greek *kephale* which means "head" and *lophus* which means "crest" and refers to the tuft of hair found on the top of the head of duikers. There are two genera (*Sylvicapra* and *Cephalophus*) with fifteen species and seventy-one subspecies. The genus *Cephalophus* contains fourteen species with forty-seven subspecies. (Grzimek, 1972). Much disagreement exists concerning the number of species of duikers (Kranz, pers. com.).

Compared to most antelope species, not a lot of information is documented concerning the duikers. Apart from the difficulty of observing duikers in their natural habitat, they are inconspicuous and are not glamorous subjects, are generally poor trophy animals and consequently they have been greatly neglected in the past (Wilson, 1987). Two factors pose the greatest threat to the survival of these species. Firstly, forest habitats are being eroded away by primitive agriculture practices and commercial exploitation. Secondly, duikers are poached extensively for their meat and skins (Wilson, 1987). Tens of thousands of duikers are killed throughout Africa each year as a source of protein for local human inhabitants; e.g. in southern Nigeria, duikers form about 25 percent of the meat eaten (Wilson, 1987).

Duikers frequent dense rain forests, dry evergreen forests, montane forests or thick bush and are found almost everywhere in Africa south of the Sahara. There is hardly a single indigenous forest without at least one species of duiker in it (Wilson, 1987).

Duikers vary in size from 3 kg (Blue Duiker) to 80 kg (Yellow-backed duiker). Cephalophids have short front legs and longer hind ones which enables the duiker to move through the thick underbrush with ease. The hooves are pointed with a wide splay and pedal glands are located between the hooves of all four feet. Duikers are very fleet footed and can escape danger with considerable speed when threatened. Duikers also will "freeze" in a standing position when threatened in order to determine the threat. Small slender horns are present in both males and females, but can be absent in females. Maxillary glands are also found.

Duikers are true ruminants with a four part stomach. They are mainly frugivores, with fallen seeds and fruits constituting approximately 60-90% of their diet. Their large mouth and wide gape enables them to pick up and crush fruits too large or hard for primates and other competing frugivores to consume. The duiker's sawlike cheek teeth are used to chew bark and roots, their mobile lips and long, pointed tongues to pluck and strip foliage, and they dig with forefeet and snouts to unearth food from the forest floor (Estes). In addition to fruits and foliage, duikers exhibit carnivorous behavior, eating a variety of other foods to include insects, birds and small mammals. Captive duikers have been recorded to stalk, catch and eat birds (Kingdon, 1982).

There is minimal sexual dimorphism, the females can be slightly larger than the males. Pre-copulatory behavior includes the male chasing the female relentlessly and periodically testing her urine. Prior to mounting the male will exhibit a foreleg kick behavior called "laufschlag". Birth is given to one offspring after a four to eight month gestation. Duiker neonates mature at a rapid rate and are indistinguishable from their parents by one year of age. Hybridization between *C. dorsalis* and *C. zebra* has been documented at the Frankfurt Zoo (Fradrich, 1964).

They are thought to be sedentary and territorial, using their preorbital glands to mark their territory by rubbing against tree branches and other objects within their territories. Duikers do not maintain dung middens but defecate at random throughout their territory. They have well defined territories and it is thought that both males and females will defend their territories against other duikers of the same species and sex (Wilson, 1987). Duikers are not gregarious, though two to three animals may be seen together at feeding locations. They are usually solitary by nature though Blue duikers live in pairs.

Duikers are diurnal, nocturnal or crepuscular depending upon the particular species. They can be inactive for long periods of the day, preferring the hollows of fallen logs or thickets in which to escape the heat of the day. Duikers are shy, rarely seen animals and very little is known about their activity patterns. Duikers are well known to use regular runs or paths through the forest and it is because of this habit that they are often snared or trapped by local people (Wilson, 1987).

CAPTIVE HISTORY

Duikers have been kept in captivity in zoological institutions, universities and by individuals in North America for over 100 years. Available records indicate that the first importation of a duiker species began with an importation of Common Duiker (*Sylvicapra grimmia*) in 1896 by the Philadelphia Zoo and have continued sporadically since. Since this initial importation in 1896, 13 species of duiker have been imported into North America with only nine species currently remaining. Specimens imported to the United States since 1945 were first quarantined for 30 days at the U.S. Department of Agriculture station at Clifton, New Jersey. The table below contains information that could be found on species that were imported into North America.

Species Name	Common Name	Date first imported into N. America	Institution imported to in N. America	Still present in N. American collections
<i>Cephalophus adersi</i>	Aders' Duiker	31 Dec 1968	Busch Gardens, Tampa, Florida	NO
<i>Cephalophus dorsalis</i>	Bay or Black-backed Duiker	???? 1948	Brookfield Zoo Chicago, Illinois	YES
<i>Cephalophus jentinki</i>	Jentink's Duiker	25 Sep 1968	Gladys Porter Zoo Brownsville, Texas	YES (males only)
<i>Cephalophus leucogaster</i>	White-bellied Duiker	15 Jun 1949	Bronx Zoo Bronx, New York	NO
<i>Cephalophus maxwelli</i>	Maxwell's Duiker	???? 1928	Philadelphia Zoo Philadelphia, Pennsylvania	YES
<i>Cephalophus monticola</i>	Blue Duiker	15 Jun 1949	Bronx Zoo Bronx, New York	YES
<i>Cephalophus natalensis</i>	Red Duiker	9 Sep 1967	Dallas Zoo Dallas, Texas	NO
<i>Cephalophus niger</i>	Black Duiker	???? 1938	National Zoological Park Washington, DC	YES
<i>Cephalophus nigrifrons</i>	Black-fronted Duiker	3 Jun 1937	Bronx Zoo Bronx, New York	NO

<i>Cephalophus rufilatus</i>	Red-flanked Duiker	???? 1962	Omaha's Henry Doorly Zoo Omaha, Nebraska	YES
<i>Cephalophus sylvicultor</i>	Yellow-backed Duiker	???? 1946	Bronx Zoo Bronx, New York	YES
<i>Cephalophus zebra</i>	Zebra Duiker	???? 1946	Omaha's Henry Doorly Zoo Omaha, Nebraska	YES (males only)
<i>Sylvicapra grimmia</i>	Common/ Grey/ Bush/ Crowned Duiker	???? 1896	Philadelphia Zoo Philadelphia, Pennsylvania	YES

Wild caught duikers have been imported from the countries of Ghana, Liberia, Kenya, Sierra Leon, Democratic Republic of Congo (formerly Zaire), Zimbabwe, Guinea and the Republic of South Africa. Duikers may have been imported from other African countries, it is unknown which, as records indicate region rather than specific location. Duikers have also been imported from individuals or institutions in Zimbabwe, Ghana, Liberia, Cameroon and Algeria. Duikers have not been imported in great numbers, resulting in a small number of founder stock for the current captive populations. A small number of North American zoological institutions have been instrumental in the importation of duikers. If an institution did not have their own ways and means of importing duikers they used animal brokers to import their animals, the most popular being International Animal Exchange Inc. or Fred J. Zeehandelaar, Inc. Duiker importation continues to take place today, though in small numbers. These importations are important in order to increase the genetic diversity of the North American captive populations.

All species of duiker that have been imported into North America have successfully produced offspring with the exception of the White-bellied Duiker (*Cephalophus leucogaster*). Duikers have shown to be non-seasonal breeders capable of producing offspring at different times of the year. The following table lists birth weights and gestation periods for select species.

Species	Gestation	Birth Weight
Bay Duiker	225-240 days	710-954 grams
Yellow-Backed Duiker	151 days	3.65 kg
Jentink's Duiker	N/A	3.289kg – 5.969kg
Maxwell's Duiker	120 days	0.94kg-1.17kg
Blue Duiker	167-205 days	710-954 grams
Common Duiker	191 days	1.3kg – 1.8kg
Red-Flanked Duiker	223-245 days	710grams-1.14 kg
Zebra-Banded Duiker	190-245 days	1.6 kg
Black Duiker	126 days	1.75 kg

Neonatal deaths have been attributed to infections, cannibalism by a parent, physical or genetic defects and environmental factors, such as hypothermia.

The lack of organized population management in the past has resulted in poor genetic diversity retention in the North American duiker populations. An increase in neonatal physical defects has been seen in the red-flanked duiker population, likely attributed to the poor genetic diversity found in this population. The Red-Flanked Duiker population has retained only 70.2%

of genetic diversity, making this the poorest genetically diverse duiker population in North America. The Black Duiker population has retained 76.6% genetic diversity and the Bay Duiker population has retained 78.3% of genetic diversity. The Yellow-backed Duiker (*Cephalophus sylvicultor*) has the best genetic diversity of all duiker species, with 90.6% genetic diversity retained. Population management plans are currently in place for Bay Duikers (*Cephalophus dorsalis*), Black Duikers (*Cephalophus niger*), Red-flanked Duikers (*Cephalophus rufilatus*), Yellow-backed Duikers (*Cephalophus sylvicultor*) and is under development for Blue Duikers (*Cephalophus monticola*). Though duikers readily breed in captivity in North America, poor genetic retention and lack of space to accommodate growing populations have resulted in low captive population densities. The success of Duikers in North America is contingent upon importing new genes into the populations and providing more space for these animals and their offspring in North American zoological institutions.

AZA ANTELOPE TAG LISTING

The 1999 AZA Antelope TAG space survey reported that there is a maximum of 217 holding spaces for duikers of which only 162 spaces are currently being used in North American facilities. The 1999 AZA Antelope TAG Regional Collection Plan for Antelopes and Giraffes recommend programs for all current duiker species except Maxwell's Duikers (*Cephalophus maxwelli*) and Common Duikers (*Sylvicapra grimmia*).

Blue, Black, Red-flanked and Yellow-backed Duikers are listed by the AZA Antelope TAG as conservation link and education populations. Conservation link and education populations are defined as a captive population that is managed in a long-term program to ensure a self-sustaining population that will require minimal input from wild populations, and which contributes to *in situ* conservation by generating interest and support for field conservation and/or may be used in educational programs as an interpretive example of conservation programs to zoo visitors. The need for released animals in field programs is not seen at this time, and the management of the captive population for release is not considered a priority (Carter, 1999). The AZA Antelope TAG has established a target captive population of 50 animals for Blue, Black and Red-Flanked Duikers. A target captive population number of 75 has been set by the AZA Antelope TAG for Yellow-Backed Duikers.

Bay Duikers are listed as a conservation support and safety net population. A conservation and safety net population is a captive population that is managed in a long-term program to ensure against the catastrophic loss of the species in the wild, and which has a component which directly links the captive program to some aspects of *in situ* conservation. Release programs or the reasonable potential for release programs are important components of most (but not all) Safety Net populations (Carter, 1999). The AZA Antelope TAG has established a target captive population number of 50 bay duikers for North America. No programs are listed by the AZA Antelope TAG for Jentink's and Zebra Duikers as currently there are only male specimens of both species in North American collections. The AZA Antelope TAG recognizes the conservation concern for Jentink's and Zebra Duikers and would include them in their collection plan for North America if a viable captive population could be established in North American zoological facilities.

CAPTIVE INFORMATION

Most duiker species, and especially duikers, are nervous, temperamental and easily frightened animals that have a highly developed flight reaction to perceived threats. For this reason, they can be very nervous or “flighty” in captive situations, reacting instantly to sudden movements. Because of this, they often ignore fences or barriers, even when they have been in an enclosure for some time and are very familiar with its boundaries. Hand raising duikers has been successful in reducing nervousness and allows the duikers to handle environmental stimulus better.

Husbandry standards for keeping small African artiodactyls cover members of the subfamily Cephalophinae and its two genera of relatively duiker weighing between 10 - 150 lb. (4 - 64 kg.) as well as several other unrelated species of small artiodactyls which possess similar husbandry needs. The species covered in this discussion include:

Common and Scientific Name	Weight	Height
Bay duiker, <i>C. dorsalis</i> *	15-24 kg	40-56 cm
Jentink’s duiker, <i>C. jentinki</i>	55-80 kg	75-100 cm
Maxwell’s duiker, <i>C. maxwellii</i>	6-10 kg	35-42 cm
Blue duiker, <i>C. monticola</i> *	3.5-9 kg	32-41 cm
Black duiker, <i>C. niger</i> *	16-24 kg	45-55 cm
Yellow-backed duiker, <i>C. sylvicultor</i> *	45-80 kg	65-87 cm
Red-flanked duiker, <i>C. rufilatus</i> *	6-14 kg	30-38 cm
Zebra duiker, <i>C. zebra</i>	15-20 kg	40-50 cm
Common duiker, <i>Sylvicapra grimmia</i>	1-25 kg	45-70 cm

The (*) indicates species with recommended programs from the AZA Antelope TAG Regional Collection Plan, third edition. The zebra duiker and jentink’s duiker are classified as endangered, but there are only males of these species left in captivity so no program is recommended unless importation takes place. The other recommended duiker species are currently classified as PMP species.

GENERAL HUSBANDRY REQUIREMENTS

ABIOTIC ENVIRONMENTAL VARIABLES

Temperature: Duikers are found in varied environments from tropical to semi-arid. Ideally duikers should be kept at 50 - 90 degrees F (10 - 32 C), avoiding extremes of cold and heat. They can tolerate cooler temperatures (40 - 50 degrees F) depending on wind chill, but should have continual access to warmer quarters away from drafts, etc. Shelter with supplemental heating elements can prolong the period of time duikers can have access to the outside in colder climates. Duikers that are kept outdoors should have access to shade as well as sunny spots to choose from to help with thermoregulation. Misters should also be provided if the duiker are to encounter temperatures above 90F for prolonged periods.

Humidity: No members of this group have special humidity requirements; ambient humidity is acceptable unless kept in extremely arid environments, then 30-50% humidity in inside enclosures is acceptable.

Illumination: Depending upon the species duiker are diurnal, crepuscular, nocturnal or active throughout the day and night. Natural light levels are sufficient for outdoor enclosures. Shady spots should be provided to animals housed outdoors. Dimly lit holding areas help to reduce the animals flight response and reduce the risk of injury. When confined to a transport crate, the animal should be kept in a dark place to help keep it calm until the transport takes place. Natural light cycles should be maintained. When kept permanently inside, lights should go on and off at the same time each day to maintain a consistent lighting interval. Fluorescent lighting is sufficient for indoor enclosure lighting, it can also be supplemented with natural lighting provided by windows in the enclosure walls or skylights. As recommended by NIH guidelines, light levels of 323 I X (30-ft. candlepower) approximately 3 1/2 feet above the floor appear to be sufficient for performance of routine animal husbandry.

Behavioral components: Duikers are not gregarious, though two to three animals may be seen together at feeding locations. They are usually solitary by nature though Blue duikers live in pairs. Duikers are shy, rarely seen animals and very little is known about their activity patterns. Enclosures for a pair of duiker weighing 1.5kg to 6 kg should be 100 feet squared. Enclosures for a pair of duiker weighing 6kg- 24 kg should be 225 feet squared, while the enclosures for a pair of duiker weighing 24kg- 80kg should measure 4000 square feet. Holding stalls for duiker should measure 8ft x 8 ft x 8ft and sizes of 12ft x 12ft x 8ft are acceptable for the larger species. The holding stall floors should be of a rough texture, either a broom finish on the floor or covered with rubber stall mats to prevent slipping. Bedding material of wood shavings, straw or hay can be used to reduce slipperiness and insulate the floor from the cold.

Duiker do better in exhibits mixed with other species. By mixing the species in the exhibit this reduces the pressure on the duiker to be in view thus reducing the stress that duiker can encounter when presented with an environment that does not provide cover. Duiker have been successfully mixed with different species of larger antelope, birds and primates. When mixing other species with duiker the exhibit space should be evaluated based on which species are to be utilizing the exhibit and increased appropriately.

Duikers should be kept in pairs, but visually separated from other pairs of the same species. Males should also be visually separated (Kranz, et al., 1998). Two male Blue Duikers (*Cephalophus monticola*) were successfully housed together at the Riverbanks Zoological Gardens. There is not a lot of information available concerning bachelor groups of duikers being kept in North American institutions. Duikers have been successfully exhibited with other mammal and bird species, adding good educational and exhibition dimensions to primate, bird or hoofstock exhibits. The following table lists the information available on duiker mixed species exhibits.

Species	Combinations	Institution	Comments
Bay Duiker	Kirk's Dik-Dik and East African Crowned Crane	Ellen Trout Zoo	Works well, duiker offspring produced
	Lesser Kudu	San Diego Wild Animal Park	Works well

	Nyala and Klipspringer	San Diego Wild Animal Park	Duiker did well with plenty of hiding places available
	Stanley Crane	Gladys Porter Zoo	
	Jentink's Duiker	Gladys Porter Zoo	
Black Duiker	Bushbuck	Los Angeles Zoo	Great display. Male Bushbuck aggressive, females fine
	White Stork	Miami Metrozoo	Works well
Blue Duiker	Sitatunga and Crane	Virginia Zoo	Works fine
	African Spoonbills	Greater Baton Rouge Zoo	
	E. African Colobus and DeBrazza Monkey	Hattiesburg Zoo	
Jentink's Duiker	Bay Duiker	Gladys Porter Zoo	
Maxwell's Duiker	Okapi	San Diego Wild Animal Park	Works well. Provide plenty of hide areas
	Mhorr Gazelle	San Diego Wild Animal Park	Works well
Red-Flanked Duiker	Moustached Guenons	Los Angeles Zoo	Exhibit worked
	Galago	Los Angeles Zoo	Animals compatible
	African spoonbill, cattle egret, abdim stork, white-faced whistling ducks	Oregon Zoo	Works well; offspring produced
	Pygmy Hippo	Houston Zoological Garden	Offspring produced
Yellow-Backed Duiker	Bongo	Cincinnati Zoo	Very successful
	Bongo, Gerenuk, Lesser kudu, birds	Columbus Zoo	Works great
	Bongo, Bat-eared fox	Los Angeles Zoo	Great display
	Greater Kudu, Springbok	Los Angeles Zoo	Male Springbok to aggressive
	Bongo	St. Louis Zoo	Not entirely successful, male Bongo terrified of male Duiker
	Okapi	San Diego Wild Animal Park	Works well, provide plenty of hide areas
	Bongo	San Diego Wild Animal Park	Works well
	Bongo, Kudu, Crowned Crane, Lappet Faced Vulture and Secretary Bird	Greater Baton Rouge Zoo	
	Bongo, Spur-winged Geese and Vulturine Guinea Fowl	Gladys Porter Zoo	

	Leadbeater's Ground Hornbill	Gladys Porter Zoo	
Zebra Duiker	Talapoins	Los Angeles Zoo	Duikers were nervous
	Crowned Lemurs	Los Angeles Zoo	Animals compatible

From: AZA Antelope Taxon Advisory Group Mixed Species Resource Manual, September 1998, edited and compiled by Anita Schanberger, Houston Zoological Gardens

Separation: Duikers can be held singly, enclosures for singly housed duiker should measure 80 square feet for duiker weighing 1.5kg to 6 kg, 120 square feet for duiker weighing 6kg- 24 kg, and 150 square feet for duiker weighing 24kg- 80kg. Holding stalls measuring the same size for a pair of small duiker should be utilized for singly housed animals. Single animals should remain visually separated from established pairs of duiker to reduce the territory defending response.

Furnishings: In the wild, many duiker rest at the base of vertical objects such as fallen logs, buttress roots or in dense brush. In their enclosures plantings should be provided as hide spots and to provide shade or cover from the elements. When kept outside, duiker should be given as large an area as possible to give a feeling of freedom of movement while enough cover (either from plantings or manmade materials) to provide a feeling of security. Tree branches and other objects should be provided to allow the animals a chance to mark their territory, these marked items should not be removed frequently as this can cause over stimulation of gland marking by the duiker. Duiker will browse on the provided vegetation, so the planting scheme of the enclosure should be plentiful enough to be able to sustain browsing pressure by these animals. For all species except Klipspringer, substrates should be relatively flat and free of too much "topography" such as hills or artificial rocks. For duiker smaller objects are fine as long as they do not unnecessarily impede the animals' view of the enclosure area or their ability to move quickly through it. The fractious nature of these animals should be taken into consideration when determining which enclosure furniture items are to be provided.

Visual, acoustic and olfactory barriers: Visual barriers such as burlap or other solid barriers should be put up around the enclosure prior to releasing a duiker into it. This solid barrier will allow the animal to get used to it's surroundings while at the same time give it a better sense of security. The solid barrier also helps to block external noise and movement outside of the enclosure, this will also help the animal settle into its new surroundings. Failure to provide this barrier could result in the animal becoming startled and running into the enclosure perimeter fence and possibly injuring itself. Once the duiker is accustomed to its environment and routine the barriers may be removed.

Substrates and nesting/bedding materials: Outdoor enclosures consisting of natural substrates with trees and bushes as plantings work best. Areas bedded with straw or hay can be provided as insulation from the ground when the temperature cools down. Concrete floors with a broom finish can be provided in the holding stalls. Shavings, straw, hay or rubber mats should be provided to reduce slippage.

Enclosure variation: New brush or limbs should be used to replace old scent marked limbs in the exhibit 3-4 times a year. Adding these items will stimulate the duiker to explore the exhibit

scent marking as they go along. Duiker enclosures do not need to be changed regularly. New plantings, soil amendments and other natural features can be changed, but not so that they restrict established pathways or panic the animals.

Substrate cleaning: Indoor hard surfaces should be cleaned and disinfected daily. Old bedding should be changed as need to maintain a dry bedding area. Outdoor enclosures should be spot cleaned daily of all fecal material, old food and old bedding.

Air changes per hour: The number of air changes per hour needed to maintain desired temperatures will vary based on enclosure size. For exclusively indoor facilities, 5 -10 air exchanges per hour is recommended.

Containment and safety: Duiker enclosures may utilize chain link, mesh, gunnite or masonite as the primary containment barriers. All enclosure walls should be solid at the bottom and free of protrusions. If using chain link it is a good idea to have a solid bottom extending 2-3 feet up to prevent injury to a limb. Enclosure walls should be six feet high minimum. Hot wire has been used with duiker, but should not be used as it may excite an animal and cause it to injure itself. If put on public view, duiker should only be visible from one side and should be given the means to distance themselves from the public, visiting members of the public should not surround the duikers. A glass- fronted exhibit with gunnite walls will cut down on patron noise.

Water Features: Water features are a good addition to duiker exhibits, but should not be considered as a means of primary containment as most duiker are good swimmers. Duikers will enter shallow pools to feed off of food items that may be placed there. The bottoms of the pools should have a broom finish to reduce slippage in case the animal gets panicked while in the pool. The pool should be drained and disinfected regularly if it is the only source of drinking water in the enclosure. If an enclosure contains a water feature the water feature should be drained, when a calf is born, to prevent drowning.

TRANSPORTATION

Type of transport container: Duikers may be transported in crates via trailers or in crates via airlines. In both situations it is important to only give the animal enough room to stand up or lie down. Too much room allows for the animal to potentially injure itself when startled. Duikers can be crate trained using operant conditioning. Crates or kennels should be left in duiker holding facilities to acclimate the animals to these containers. Food or treat items can be placed in the crates to keep the duiker crate trained. By doing this it will make it easier to crate the animal on the day of the shipment as nothing but closing the crate door is different in the animals' routine. Once crated the animal should be kept in a dark quiet area until transport in order to reduce stress and to reduce potential for being startled. IATA-approved containers suitable for shipping duiker by air must be made from solid wood or metal parts bolted or screwed together. The insides of the container must be smooth. When the weight of the animal plus the container exceeds 132 lbs., metal bracing must be added to the frame and forklift space bars are to be provided. Hinged or sliding entry and exit doors must be provided. The doors must have a way to be securely fastened so they cannot be accidentally opened during transport.

Space bars/handles should be made to a depth of 1-inch on the sides of the container. If animals are to be transported over land, similar shipping containers should be used.

Appropriate size of transport container: The height and width of the container must allow the animal to stand erect with its head extended, even if horned. The size of the container must sufficiently restrict movement so that the animal cannot turn around, nor have space to kick and damage the container. The dimensions will vary according to the species being shipped. Ventilation holes of 1-inch must be provided to cover 20% of the total area of the surface of all four sides. Ventilation holes should be placed above the eye level of the duiker. This helps to restrict the animals' exposure to outside stimulus while at the same time increasing the feeling of security for the animal, while it is in the crate.

Food and Water: Duiker do not normally require additional food and water during the first 24 hours of transport. Food and water containers must be provided with outside access from a hinged bolted door that allows for the addition of a water bowl and food in case of an unforeseen delay in transport. Feed should accompany the transport to be provided in the case of a delay. Animals being transport by land should be given access to water 3-4 times a day during transport in hotter times of the year.

Bedding during transport: The floor of the crate should be solid and leak-proof. A rubber mat can be installed to prevent slippage and straw, hay or shavings should be used to absorb any liquids.

Flooring: The floor of the crate should be solid not slatted. A slatted floor can cause hoof or leg injuries. The floor should be leak proof to prevent spillage of urine and feces.

Temperature range during transport: General temperatures permitted by airlines for transport of live animals are 45-85 degrees F. Duiker should be transported at 50-85 degrees F. When transporting at lower temperatures or in an unheated trailer, bedding such as straw and hay should be provided as insulation from the cold.

Group size: Due to their fractious nature, duiker of all ages should be transported in individual containers.

Access during transport: Duiker can be transported by air without staff accompanying them. Access to duiker during air transport should be limited to providing food and water in the case of a delay causing the total transport time to exceed 24 hours. Duiker should not be accessed during air transport as this can excite the animal and possibly cause injury. Duiker being transported by land that take longer than 24 hours can be accessed to provide food or water through the access door in the crate.

Length of transport: Animals being transported over land can tolerate 3-5 days in their crate as long as food and water are provided.

BIOTIC VARIABLES

Food and Water

Water: Fresh clean potable water should be available at all times. Water can be offered inside or outside using plastic, rubber or stainless steel containers, automatic float drinkers can also be used. Water containers should be cleaned and disinfected daily. If the sole source of water is a water feature within the enclosure, such as a pool or stream, then these features should be cleaned and disinfected weekly.

Food: Duikers are simultaneously browsers and frugivores being described as primitive ruminants with significant cecal fiber fermentation. In captivity duiker are easily maintained on good quality hay, mixed grains, vegetables and trace mineral blocks. Commercial fruits such as apples, bananas and oranges are high in sugars and should be used as treats for training rewards. Duiker diets should be supplemented with a variety of browse. Coarse stemmy hay should be avoided as mouth abscesses can occur from stem punctures.

Feeding: Duikers should be provided their hay ad lib, the produce and pellets should be fed daily in containers to keep the food off of the ground and reduce spoilage. Salt and mineral blocks can be offered ad lib as well. Browse should be placed around the enclosure or holding area to encourage the animal to move about the area. In some groups the male will attempt to dominate the browse or choice food items. In this case the food and browse should be separated and fed in several locations to insure that all group members get access.

Enrichment feeding: It is best to offer browse or scatter food items as enrichment. Duiker can react in a sudden manner when confronted with new items introduced into their exhibit.

SOCIAL CONSIDERATIONS

Age and sex structure of social group: Duiker is usually found singly, in pairs or pairs plus one offspring. In captivity, many species may be kept in groups although evidence from field studies suggests that for maximum reproductive success, all species should be maintained in pairs. In the case of blue duiker and dik-dik, monogamous pair bonding has been confirmed. Duiker will establish territories and defend these territories when needed, thus same species groups should not be housed next to each other unless visual barriers are provided.

Captive breeding strategies: Duikers reach sexual maturity at a young age, some species as young as 1 year old. Usually a single calf is born after a gestation of 120-240 days depending upon the species. A well-bedded covered area should be provided to the female for birthing. Duikers are non-seasonal breeders, so for births occurring in the colder months, the female should be kept in a warm dry location. Calves can be born on exhibit or in holding, whichever causes less stress to the female. Handraising is successful at calming duiker down and should be done if the mother cannot raise the young on her own. Handraised individuals, both male and female, have grown to be proven breeders and have made for good parents to their own calves.

Temporary isolation of pregnant females: Females generally do not need to be isolated when giving birth or raising calves. Males can be left with the females during parturition, but neonatal injury and mortality due to aggression from the male towards the calf has been recorded for several species. The male should be watched closely and if aggressive displays toward the calf are noted then the male should be separated until the calf is strong and mobile.

Nursery groups: Duiker calves are raised by their dams, though males of some species will respond to a calf's distress call.

Forced "emigration" of adolescents: Duiker mature at a young age, due to this fact the calves should be removed from their family group by 6-8 months of age. Failure to do this may result in inbreeding from the sire to the female calf or the male calf to the dam. AZA Antelope TAG recommended duiker species are being managed through studbooks and Population Management Plans. Handling of surplus individuals should be accomplished with input from these managers.

Introductions: Initial pair formation can be done at any age after calf weaning. Individuals should be housed next to each other, for a couple of weeks, providing for visual, and olfactory contact. If being introduced together in a new enclosure, each individual should be given time alone in the enclosure to get used their surroundings. Visual barriers such as burlap should be installed all along the perimeter fence during the introduction period. After each animal becomes familiar with the enclosure they can be introduced together. There will be a good amount of chasing of the female by the male as he tests the female for receptiveness. Aggression between males and females is rare, aggression is mainly noted in same sex introductions.

Mixed species groups: Duikers do well in mixed species groups, sometimes it is the more preferable method of exhibiting duiker as it does not maintain the focus on these shy animals. Duikers have been successfully housed with other small antelope, medium to large hoofstock, birds and to some degree primates. Duiker of the same species should not be housed together as hybridization can occur.

Human-animal interactions: Duiker respond well to established keeper routines. When working in an enclosure distance should be kept between the keeper and the animals, giving the animals flight paths if needed. Duiker will respond well to keepers and operant conditioning regimens, especially when the individual has been handraised. A radio playing in the barn provides background noise to help keep the animals desensitized to unusual sounds. Keepers should announce their presence by using familiar sounds, such as rattling their keys, whistling, or speaking softly to the animals. Sudden appearances should be avoided as this can startle the animal and possibly cause injury or death.

HEALTH AND NUTRITION

Nutrient requirements: Most small antelope do well with a basic diet consisting of good quality grass hay, commercial pellets and assorted browse, supplemented with small amounts of fruits or vegetables. Duiker nutritional needs are more specific than the other small antelope. Looking at captive diets of duikers and comparing them to the wild diet, it has become evident that the domestic fruits fed to duikers in captivity are not well suited for them. Domestic fruits contain

80-90% sugar and 1-4% fiber. Whereas, the wild fruits eaten by duikers are less than 50% sugar and are 14-62% fiber. The wild fruits, such as Rheedea, Licania, and Clusia contain chemicals and tannins not found in the domestic fruits (Holland pers. comm.). The following are sample diets that are fed at the Los Angeles Zoo.

Red-flanked duiker diet for 1.1 animals

Free choice alfalfa hay
 2 quarts Mazuri browser maintenance pellets
 Browse
 1 bunch broccoli or spinach (alternated every other day)
 _ pound squash (butternut or acorn)
 _ pound carrots

Black duiker diet for 1.1 animals

Free choice alfalfa hay
 3 quarts Mazuri browser maintenance pellets
 Browse
 1 bunch spinach or broccoli (alternated every other day)
 _ pound squash (butternut or acorn)
 _ pound carrot

The following table outlines the browse species fed to duikers at the Los Angeles Zoo.

Common Name	Scientific Name	Comments
Acacia	<i>Acacia sp.</i>	Well liked depending on species
Cape Plumbago	<i>Plumbago auriculata</i>	Well liked
Mulberry	<i>Morus sp.</i>	Well liked – seasonal
Fruitless Mulberry	<i>Morus alba</i>	Well liked –seasonal
Cottonwood	<i>Populus sp.</i>	Well liked – seasonal
Chinese Elm	<i>Ulmus parvifolia</i>	Some individuals like
Natal Plum	<i>Carissa grandiflora</i>	Well liked – watch the thorns
Hibiscus (flowers & leaves)	<i>Hibiscus sp.</i>	Well liked
Eugenia	<i>Eugenia sp.</i>	Some individuals like
Ficus	<i>Ficus benjamina</i>	Some individuals like
Evergreen pear	<i>Pyrus kawakamii</i>	Well liked
Rose flowers	<i>Rosa rugosa</i>	Well liked
Loquat (leaves only)	<i>Eriobotra japonica</i>	Some individuals like
Mimosa or silk tree	<i>Albizia julibrissin</i>	Some individuals like
Kaffir plum	<i>Harpephyllum caffrum</i>	Some individuals like
Flowering plum	<i>Prunus cerasifera</i>	Well liked
Jacaranda	<i>Jacaranda mimosifolia</i>	Some individuals like

Medical Management: The services of a veterinarian experienced in bovine diseases should be available.

Preshipment exam: Prior to accepting new animals, the following results from a most recent physical exam, CBC, chemistry panel, R/C, *Brucellosis*, *Mycobacterium paratuberculosis* (Johnes), TB test, fecal screening for parasites and mineral/vitamin analysis should be obtained. Specific tests may vary depending upon the destination of the animal. Complete records (ARKS and MedARKS), current diet and behavior information from the sending institution should also

be obtained. During the preshipment exams permanent identifications (ear notch, tag, microchip, etc.) can be done.

Quarantine and hospitalization: All incoming duiker should be quarantined for at least 30 days. Each animal should receive a complete physical examination during the quarantine period. Other tests include:

- Three fecal exams (direct and floats)
- CBC, chemistry panel and serum for banking
- X-rays
- External parasite check
- Permanent identification (ear tag, microchip, etc.) if not already done
- Mycobacterium paratuberculosis* (Johnes) if desired.

Preventative medicine (testing, vaccinations, etc.): Complete physical exams should be done annually. These exams should include blood draw for CBC, chemistry panel, serology for *leptospirosis serovars* and serum banking, TB test, obtain weight, mineral/vitamin analysis and external parasite check. In addition to the annual exam duikers should receive fecal examinations (direct and float) twice a year. No vaccinations are recommended for all regions although some particular regions may dictate that animals be immunized against rabies, clostridial diseases (C and D, and tetanus), bovine viral diarrhea, and equine encephalides.

Capture, restraint and immobilization techniques: If it all possible capture and restraint of duiker should be avoided. Duiker are easily prone to capture myopathy and regurgitation that could often lead to aspiration pneumonia. Development of training procedures relevant to capture and restraint should be formulated and implemented. Conditioning, or otherwise desensitizing individuals to allow for weighing, crating or shipment, some veterinary procedures or (at minimum) ease of capture and restraint is highly desirable. Recent immobilization utilizing Carfentanil 40.431mcg/kg and Medetomidine 8.985mcg/kg was successful. The animal was fasted for 48 hours to reduce the possibility of regurgitation during the anesthesia. Isoflurane 1.5% in O₂ via endotracheal tube is utilized to keep the animal anesthetized during lengthy procedures. Atipamezole 41.667mcg/kg and Naltrexone 37.5mcg/kg was used successfully to reverse the immobilization agents. Duiker can be manually restrained to receive the immobilizing drugs via injection and then left in a kennel while observing for initiating effects or closed in a modified crate that allows for the administering of isoflurane gas. Duiker can be manually restrained for short procedures such as TB tests, injections, etc. The animal can be acclimated to a crate or kennel then keepers can use a net to catch the animal as it exits the crate. Once in the net one keeper should restrain the rear leg and the other keeper restrain the head and front legs. Caution should be used to avoid injury from the upward stabbing with horns or, in the case of duikers, being bitten. Duiker can also be caught in small enclosures utilizing a net and the above-mentioned restraining technique. Whenever restraining or immobilizing duiker it is important to keep the animal in a sternal position and not to apply pressure on the abdomen to reduce the incidence of regurgitation. For all procedures the time of the procedure should be kept to a minimum to reduce the possibility of complications associated with capture, restraint and immobilization.

Management of neonates: Duiker calves should be examine within 24-48 hours post birth. The calf should be given a thorough physical exam, sexed, weighed, given a vitamin E injection,

permanently identified (ear notch, microchip, etc) and have the umbilicus cleaned and dipped in iodine. Blood should also be collected for complete blood count and serum chemistry panel. If possible the umbilicus should be cleaned and dipped in betadine until the stump falls off at approximately one week.

Management during pregnancy: Females can be left with the male through out the pregnancy and parturition, unless there is a history of aggression towards calves from the male. If this is the case then the male should be separated from the female prior to birth. The female will become larger during her pregnancy, her food consumption will increase and her nipples will become larger prior to parturition.

REPRODUCTION

Seasonality of reproduction: Duiker breed throughout the year and seasonality of reproduction is not evident. Estrus occurs approximately once a month and will last for two to three days. Facilities in colder climates will want to regulate breeding so as to minimize calves being born during the colder months. Given appropriate housing calves can be born in the colder months if suitable heat is provided to the calf and dam. Gestation periods differ between species.

Hormonal tracking as a mechanism for identifying reproductive state: To date this form of testing has not occurred for duiker, but would be beneficial for management purposes.

Introduction of solitary species: Duiker can be housed singly or in pairs. Pairs not intended to breed should be contracepted.

Female management during parturition: Females can give birth on exhibit or in holding stalls, whichever provides a setting that the female is most comfortable in. Confining females to holding stalls for birth will make it easier to restrain the calf and perform neonatal exams. If the male has to be separated prior to birth, then standard introduction techniques should be used when introducing the male to the female and calf. Introductions should take place once the female demonstrates good rearing behavior and the calf is strong and mobile.

Hand rearing protocols: Duiker calves should be pulled for handrearing in order to keep the animals in a relatively calm state, thus making long term management of these animals safer and less stressful. If the dam and sire are calm and tractable then leaving the calf with them usually results in a calm and tractable calf. Handraised calves have demonstrated the ability to be good parents when adults. Calves should be left with the dam for 24 hours to insure that colostrum intake occurs. Calves left longer than 24 hours have proved difficult to get on a bottle. Duiker calves are kept at 70F and fed six times a day at three-hour intervals. Weaning begins at day sixty and is usually completed at 93-100 days.

Means and duration of contraception: Reversible contraception can be accomplished with the use of MGA implants or Depo-Provera injections for up to two years. Use of these methods past two years without an intervening pregnancy could have possible deleterious uterine effects. Hysterectomy or vasectomy is acceptable permanent contraception techniques. Porcine zona pellucida vaccine has not been used in duikers.

BEHAVIOR MANAGEMENT

Training for routine husbandry procedures: Routine husbandry needs such as crate training, hoof trimming, shifting from one area to another, tolerating close proximity of the keeper and tolerating close visual inspection has been trained successfully through positive reinforcement training. Duiker respond well to voice commands and food rewards.

Training for non-routine husbandry procedures: As in above, positive reinforcement training has been used successfully for duiker. Scale platform training for obtaining daily weights, obtaining rectal temperatures, obtaining milk samples from lactating females, crate training to reduce the stress of transport and to facilitate capture for procedures as well as physical inspection and manipulation of duiker has been successfully trained with several duiker species. The use of vocal commands or target training has been successful as well.

Introduction techniques: Duiker can be housed in singles or pairs. Introductions should take place over a period of time and moving from step to step in the introduction process should be based upon the animal's behavior. Duiker should be given visual and olfactory contact through a barrier prior to actual introduction. Each animal should be given the opportunity to explore and become comfortable with the introduction area prior to being introduced to each other. Solid barriers such as burlap should be put up around the introduction area perimeter fencing to prevent the animals from injuring themselves if they get stressed. The animals should be introduced together with keeper supervision, and a plan should be in place to separate the animals if aggression is noted. Each animal should have access to his or her own holding stall during the introduction process. Once the pair looks to be compatible the perimeter fencing barriers can be taken down.

Facility design and training techniques: Duiker can be trained using voice commands and targets when done in conjunction with positive rewards. Duiker can be trained in free contact and rewards can be delivered by hand or placed near the animal when given.

Effective techniques: Successful training programs include those that involved establishing training goals by the entire staff. Goals are accomplished by developing training plans that define training steps, cues and criteria for the desired behaviors. Progress of training plans should be monitored and evaluated. Once the desired behavior is obtained it should be maintained on a regular basis.

Keeper skills: Staff familiar with the husbandry and daily routines of duiker should be well prepared for maintaining these species.

BIBLIOGRAPHY

- Ansell, W.F.H. 1971. Order Artiodactyla. Pp. 1-84, In: THE MAMMALS OF AFRICA, AN IDENTIFICATION MANUAL. Part 15 (J. Meeseter and H.W. Setzer, eds.) Smithsonian Inst. Press, Washington, DC 15:1-84.
- Ape Alliance, c/o Fauna & Flora International. The African Bushmeat Trade- A Recipe for Extinction. 1998.
- Barnes, R., Greene, K., Holland, J., Lamm, M. Management and Husbandry of Duikers at the Los Angeles Zoo. ZOO BIOLOGY vol. 21 no.2: 107-121, 2002.
- Boitani, L., Et. Al. A DATABANK FOR THE CONSERVATION AND MANGEMENT OF THE AFRICAN MAMMALS pp. A-880-A-883, A-908-A-911, A924-A-927. Italy, 1999.
- Bowman, V., Plowman, A. Captive Duiker Management at the Duiker and Mini-Antelope Breedig and Research Institute (Dambari), Bulawayo, Zimbabwe. ZOO BIOLOGY, vol. 21 no. 2: 161-170, 2002.
- Carter, S., ed. ANTELOPE ADVISORY GROUP REGIONAL COLLECTION PLAN FOR ANTELOPES AND GIRAFFES, Third Edition. 1999.
- Chan, S., ed. Animal Keeper's Forum, Special Issue- Duiker Management and Conservation. Vol. 27, No. 11, November 2000.
- Crandall, L.S. Order Artiodactyla. Pp 654-658 in MANAGEMENT OF WILD ANIMALS IN CAPTIVITY. Chicago, The University of Chicago Press, 1964.
- Crotty, M. Mixed species exhibits at the Los Angeles Zoo. Pp 203-206 in INTERNATIONAL ZOO YEARBOOK, vol. 21. P.J.S. Olney, ed., London, The Zoological Society of London, 1981.
- Conklin-Brittain, N.L. Dierenfeld, E.S., Small Ruminants: Digestive Capacity Differences Among Four Species Weighing Less Than 20 Kg. ZOO BIOLOGY 15:481-490, 1996.
- Dierenfeld, E., Mueller, P., Hall, M., Duikers: Native food Composition, Micronutrient assessment, and Implications for Improvong Captive Diets. ZOO BIOLOGY, vol. 21 no. 2: 185-196, 2002.
- Dittrich, L. Birth weights and weight increases of African antelopes born at Hanover Zoo. Pp. 118-120 in INTERNATIONAL ZOO YEARBOOK, vol. 9. J. Lucas, ed., London, The Zoological Society of London, 1969.
- Dittrich, L. Gestation periods and age of sexual maturity of some African antelopes. Pp. 184-187 in INTERNATIONAL ZOO YEARBOOK, vol. 12. J.Lucas, N. Duplaix-Hall, ed., London, The Zoological Society of London, 1972.

Dittrich, L. Food presentation in relation to behaviour in ungulates. Pp. 48-54 in INTERNATIONAL ZOO YEARBOOK, vol. 16. P.J.S. Olney, ed., London, The Zoological Society of London, 1976.

Dittrich, L. Some further birth weights of African antelopes born at Hanover Zoo. Pp. 201 in INTERNATIONAL ZOO YEARBOOK, vol. 19. P.J.S. Olney, ed., London, The Zoological Society of London, 1979.

East, R. ANTELOPE SURVEY UPDATE, IUCN/SSC ANTELOPE SPECIALIST GROUP, no.1. August 1995.

East, R. ANTELOPE SURVEY UPDATE, IUCN/SSC ANTELOPE SPECIALIST GROUP, no. 2. September 1996.

East, R. ANTELOPE SURVEY UPDATE, IUCN/SSC ANTELOPE SPECIALIST GROUP, no. 3. December 1996.

East, R. AFRICAN ANTELOPE DATABASE, IUCN/SSC ANTELOPE SPECIALIST GROUP REPORT. December 1998.

Estes, R.D. Duikers: tribe cephalophini. Pp. 26-31 in THE BEHAVIOR GUIDE TO AFRICAN MAMMALS. Berkeley, The University of California Press, 1991.

Farst, D.D., Thompson, D.P., Stones, G.A., Burchfield, P.M., Hughes, M.L. Maintenance and breeding of duikers, *Cephalophus* spp., at Gladys Porter Zoo, Brownsville. Pp. 93-99 in INTERNATIONAL ZOO YEARBOOK, vol. 20. P.J.S. Olney, ed., London, The Zoological Society of London, 1980.

Fradrich, H. Beobachtungen zur kreuzung zwischen Schwarzruckenducker, *C. dorsalis* und *C. zebra*. Zeitschrift fur Saugetierkunde 29:46-51, 1964.

Frahm, M.W., Medical Management of Duikers. Pp. 668-681 in ZOO & WILD ANIMAL MEDICINE CURRENT THERAPY 4. M. Fowler, R. Miller, ed., Philadelphia, W.B. Saunders Company, 1999.

Gautier-Hion, A.; Emmons, L.H. and G. Dubost. 1980. A comparison of the diets of three major groups of primary consumers of Gabon (primates, squirrels and ruminants). OECOLOGICA. 45:182-189.

Grisham, J., Savage, B. Hoofstock management at the Oklahoma City Zoo. Pp. 212-219 in INTERNATIONAL ZOO YEARBOOK, vol. 29. P.J.S. Olney, P. Ellis, ed., London, The Zoological Society of London, 1989.

Grubb, P. Order Artiodactyla. Pp. 410-412 in MAMMAL SPECIES OF THE WORLD: A TAXONOMIC AND GEOGRAPHIS REFERENCE, Second Edition. D. Wilson, ed., Washington, Smithsonian Institution Press, 1993.

Hayssen, V., Van Tienhoven, Ar., Tienhoven, An. Order artiodactyla, family bovidae. Pp. 418-419; 424; 431; 435; 437; 442; 450 in ASDELL'S PATTERNS OF MAMMALIAN REPRODUCTION, A COMPENDIUM OF SPECIES-SPECIFIC DATA. Ithaca, Cornell University Press, 1993.

Honacki, J.H.; Kimman, K.E. and J.W. Koepl 1982. MAMMALS SPECIES OF THE WORLD, A TAXONOMIC AND GEOGRAPHIC REFERENCE. Allen Press, Inc. and Association of Sytematics Collections, Lawrence, KS. 694 pp.

Jones-Bowen, E. A review of the commercial bushmeat trade with emphasis on Central/West Africa and the great apes. Pp S1-S37 in AFRICAN PRIMATES THE NEWSLETTER OF THE AFRICA SECTION OF THE IUCN/SSC PRIMATE SPECIALIST GROUP, vol. 3, Numbers 1 & 2. T. Butynski, Senior ed., 1997-1998.

Kendall, G., Rieches, R., ed. ANTELOPE HUSBANDRY MANUAL: CEPHALOPHINAE, San Diego Zoological Society, First edition, 2000.

Kingdon, J. Duikers. Pp. 269-279; 291; 314-317 in EAST AFRICAN MAMMALS, AN ATLAS OF EVOLUTION IN AFRICA, vol. III part C (Bovids). London, Academic Press, 1982.

Kranz, K.R., Lumpkin, S. Notes on the Yellow-backed duiker, *Cephalophus sylvicultor*, in captivity with comments on its natural history. Pp. 232-240 in INTERNATIONAL ZOO YEARBOOK, vol. 22. P.J.S. Olney, ed., London, The Zoological Society of London, 1982.

Kranz, K., La Rue, F. Small African Bovids and Chevrotains in AZA'S MINIMUM HUSBANDRY GUIDELINES FOR MAMMALS. 1998.

Mader, H., CITES MANUAL OF IDENTIFICATION, vol. 1a. 1984.

Meester, J., Setzer, H.W. Order artiodactyla. Pp. 28-29; 31; 33-35 in THE MAMMALS OF AFRICA: AN IDENTIFICATION MANUAL. City of Washington, Smithsonian Institution Press, 1971.

Nowak, R.M., ed. WALKER'S MAMMALS OF THE WORLD 5TH EDITION, vol II. Baltimore, The Johns Hopkins University Press, 1991.

Peal, A., Kranz, K. Liberia. Pp. 47-51 in ANTELOPES GLOBAL SURVEY AND REGIONAL ACTION PLANS, PART 3 WEST AND CENTRAL AFRICA. R. East, ed. 1990.

Pfefferkorn, C. North American Regional Studbook Duiker (*Cephalophus dorsalis*, *Cephalophus niger*, *Cephalophus rufilatus*, *Cephalophus zebra*), First Edition, 1998.

Pfefferkorn, C. North American Regional Studbook Duiker (*Cephalophus dorsalis*, *Cephalophus niger*, *Cephalophus rufilatus*, *Cephalophus zebra*), Annual Update, 1999.

- Pfefferkorn, C. North American Regional Studbook Duiker (*Cephalophus dorsalis*, *Cephalophus niger*, *Cephalophus rufilatus*, *Cephalophus zebra*), Annual Update, 2000.
- Pinchin, A. The Pan-African decade of duiker research--an integrated programme of field and captive based conservation. INTERNATIONAL ZOO NEWS 40/3: 16-21.
- Plowman, A. Nutrient Intake and Apparent Digestibility of Diets Consumed by Captive Duikers at the Dambari Field Station, Zimbabwe. ZOO BIOLOGY vol. 21 no. 2: 135-147, 2002.
- Ralls, K., Kranz K. Duikers. Pp. 556-559 in THE ENCYCLOPEDIA OF MAMMALS. D. Macdonald, ed., New York, Facts on File Publications. 1984.
- Robertia, J. Guidelines for establishing training and conditioning protocols for captive duikers. Animal Keeper's Forum, 463-481. Vol. 27, No. 11, November, 2000.
- Schanberger, A., ed. ANTELOPE MIXED SPECIES RESOURCE MANUAL- ANTELOPE TAXON ADVISORY GROUP. September 1998.
- Shaffstall, W. AFRICAN HOOFSOCK SURVEY: RESULTS OF HUSBANDRY QUESTIONNAIRE. 1997.
- Shurter, S. ANTELOPE TAXON ADVISORY GROUP REGIONAL ACTION PLAN, DRAFT II. 1997.
- Spratt, K., ed. Husbandry, Nutrition and Health of Captive Duikers International Workshop, St. Catherines Island Wildlife Survival Center. March 24-26, 2000.
- Taylor, Steve H., Bietz, Alan D. AAZPA Infant Diet/ Care Notebook. A publication of the American Association of Zoological Parks and Aquariums. 1985.
- Thomas, W.D. 1973. Miscellaneous notes on duiker (Genus *Cephalophus*). Proc. 1973 AAZPA Central Regional Conference, Houston, TEXAS. Ralston Purina, Topeka, KS.
- Thomas, W.D., Barnes, R., Crotty, M., Jones, M. An historical overview of selected rare ruminants in captivity. Pp. 77-99 in INTERNATIONAL ZOO YEARBOOK, vol. 24/25. P.J.S. Olney, ed., London, The Zoological Society of London, 1984/1985.
- Udell, C. Breeding the Zebra duiker, *Cephalophus zebra*, at the Los Angeles Zoo. Pp. 155-158 in INTERNATIONAL ZOO YEARBOOK, vol. 21. P.J.S. Olney, ed., London, The Zoological Society of London, 1981.
- Walther, F. Duikers, Dwarf Antelopes, and Tragelaphinae. Pp.308-311 in GRZIMEK'S ANIMAL LIFE ENCYCLOPEDIA, vol. 13, Mammals IV. B.Grzimek,Dr.Dr.h.c., ed., New York, Van Nostrand Reinhold Company, 1972.
- Willette, M., Norton, T., Miller, C., Lamm, M., Veterinary Concerns of Captive Duikers. ZOO BIOLOGY, vol. 21 no.2: 197-207, 2002.

Wilson, V.J. ACTION PLAN FOR DUIKER CONSERVATION. Bulawayo, Chipangali Wildlife Trust, 1987.

Wilson, V.J. News Sheet No. 1. PAN AFRICAN DECADE ON DUIKER RESEARCH (1985-1994). 1986.

Wilson, V.J. News Sheet No 2. PAN AFRICAN DECADE ON DUIKER RESEARCH (1985-1994). Dec. 1987.

Wilson, V.J. News Sheet No. 3. PAN AFRICAN DECADE ON DUIKER RESEARCH (1985-1994). Dec. 1988.

Wilson, V.J. News Sheet No. 4. PAN AFRICAN DECADE OF DUIKER RESEARCH (1985-1994). Dec. 1989.

Wilson, V.J. Why the Indigenous People of Africa Need Duikers, An Appeal for Funding. PANAFRICAN DECADE OF DUIKER RESEARCH (1985-1994). Jun. 1990.

Wilson, V.J. News Sheet No. 5. PAN AFRICAN DECADE OF DUIKER RESEARCH (1985-1994). Aug. 1990.

Wilson, V.J. News Sheet No. 6. PAN AFRICAN DECADE OF DUIKER RESEARCH (1985-1994). Dec. 1990.

Wilson, V.J. The Duikers of Ghana. April 1994.

Wilson, V.J., DUIKERS OF AFRICA Masters of the African Forest Floor. Chipangali Wildlife Trust. Bulawayo, Zimbabwe. 2001